

Effects of the antioxidant properties of millet species on oxidative stress and glycemic status in alloxan-induced rats

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Abstract

Reactive oxygen species play a significant role in accelerating the complications of diabetes mellitus, and antioxidants alleviate these effects. Finger millet (FM; *Eleusine coracana*) and kodo millet (KM; *Paspalum scrobiculatum*) are rich sources of phenolics, tannins, and phytates, which can act as antioxidants. Hence, the beneficial role of a millet-based diet in protecting against oxidative stress and maintaining glucose levels in vivo in type II diabetes was investigated. Whole grain flour of finger millet and KM was incorporated at 55% by weight in the basal diet fed to alloxan-induced diabetic rats over a period of 28 days. Blood glucose, cholesterol, enzymatic and nonenzymatic antioxidants, lipid peroxides in blood plasma, and glycation of tail tendon collagen were measured. The rats fed the KM-enriched diet showed a greater reduction in blood glucose (42%) and cholesterol (27%) than those fed the finger millet (36% and 13%). The levels of enzymatic (glutathione, vitamins E and C) and nonenzymatic antioxidants (superoxide dismutase, catalase, glutathione peroxidase, and glutathione reductase) and lipid peroxides were significantly reduced in diabetic animals and restored to normal levels in the millet-fed groups. Glycation of tail tendon collagen was only 40% in the finger millet-fed rats and 47% in the KM-fed rats compared to the controls. Diets containing whole grain millet meal flour can protect against hyperglycemic and alloxan-induced oxidative stress in Wistar rats.

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1. Introduction

India is the largest producer of many kinds of millets called coarse cereals [1]. The small millets include 6 main grain crops which are finger millet (*ragi* in Tamil vernacular or *Eleusine coracana*), kodo millet (*varagu* or *Paspalum scrobiculatum*), little millet (*samai* or *Panicum sumatrense*), foxtail millet (*tenai* or *Setaria italica*), proso millet (*panivaragu* or *Panicum milliaceum*), and barnyard millet (*kudiraivali* or *Echinochloa frumentacea*). Small millets are important at the regional and farm level because they contribute to the widening of the food basket, which is narrow because of the dependence on rice and wheat [1]. Millet has been cultivated for more than 5000 years and is a dry land crop grown in marginal and hilly agricultural regions. Finger millet (FM) ranks fourth in production after wheat, rice, and maize in India.

Despite the superior nutritive value of the millet, their use in rural areas exceeds that in urban markets [1]. The consumption pattern varies from region to region. Karnataka State has the largest area of about 1 million hectares (50% of the total area) for cultivating finger millet, whereas the cultivation of kodo millet is more prevalent in Madhya Pradesh, covering about 1 million hectares [1]. In Southern Karnataka, 100% of the rural population and 94% of the urban population consume finger millet as a traditional food called *mudde* or thick porridge [2]. Kodo millet (KM) is an important food crop for vast sections of the tribal community in Central India. Thus, for these people, millet is the major food for 6 to 9 months in a year [2].

Small millets are superior to rice and wheat as a source of dietary fiber and certain minerals (Table 1) [1,3]. Finger millet has the highest Ca content among all cereals (344 mg per 100 edible portion) and has high levels of phytate, Zn, and P (Table 1) [1,3]. Kodo millet has a higher amount of dietary fiber and iron than FM. The millet grain contains about 65% to 72% carbohydrates, a high proportion of which is nonstarchy polysaccharides and dietary fiber. The fat from FM contains a high proportion of essential fatty acids, and the protein has a balanced essential amino acid profile [1].

Finger millet and KM are also well known for their antinutrient constituents such as trypsin inhibitors, phytates, phenols, and tannins. Recently, antinutritional factors in plant-based foods are in focus to understand their potential health benefits [4]. Dietary fiber protects against hyperglycemia, phytates against oxidative stress by chelating iron involved in Fenton's reaction, and some phenolics and tannins act as antioxidants [4,5]. We reported higher antioxidant activity in the phenolic extracts of KM and FM than in other millets and cereals [6,7].

Although there are some nutritional studies on FM and its fractions contributing to an improved protein energy status [8,9], there is no study that evaluates the effects on glycemic control. Oxidative stress and hyperglycemia in diabetes produce reactive oxygen species, which causes peroxidation of membrane lipids, protein glycation, and health complications such as retinopathy, neuropathy, nephropathy, and vasculopathy [10]. Antioxidants inhibit glycation by scavenging reactive oxygen species, and superoxide dismutase (SOD) and metal chelators protect against alloxan-induced diabetes in animals [11].

The WHO predicts that the number of diabetics worldwide is 150 million and that number would double by the year 2005. India has a higher incidence of diabetes than any other country with estimates ranging from 19.4 million in 1995 to 32.7 million in 2000 [12]. Type 2 diabetes constitutes 90% of the diabetic population. Epidemiological studies among migrant

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